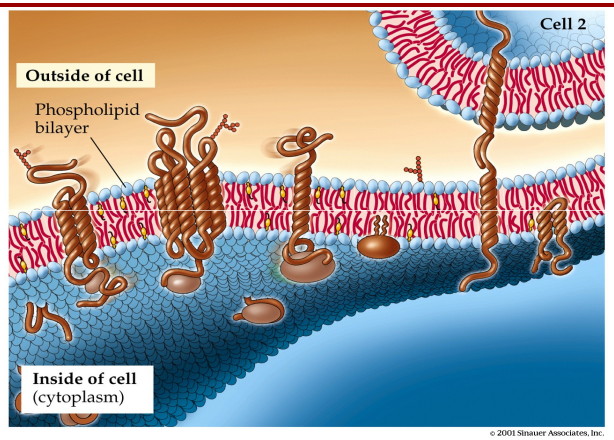
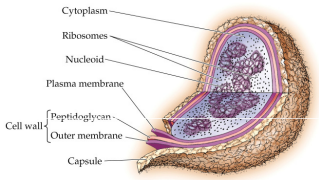
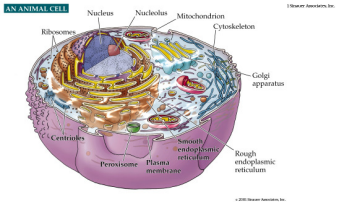
Cell Membranes



Where are membranes found in cells?

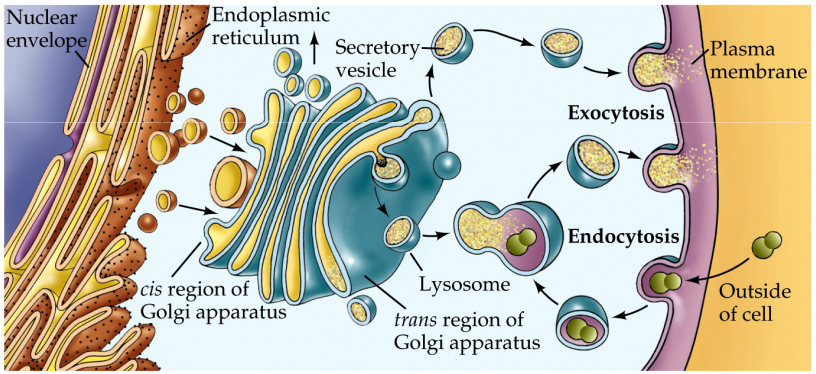
- Archaea and Gram-positive bacteria have one membrane
- Gram-negative bacteria have two membranes
- Eukaryotic cells have many membranes





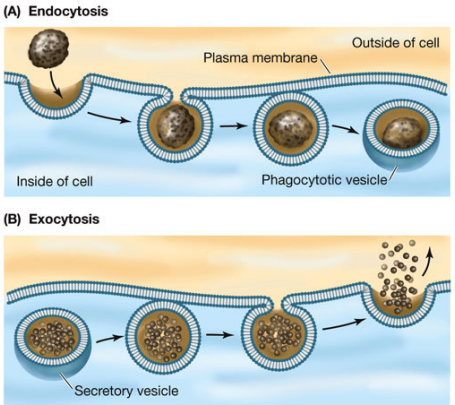
Membranes are dynamic

- The secretory and endocytotic pathways



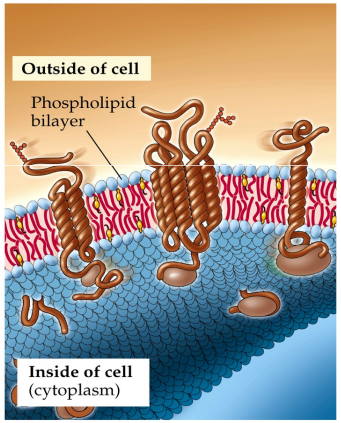
Endocytosis and exocytosis

- NB: only in eukaryotes!



What are membranes made of?

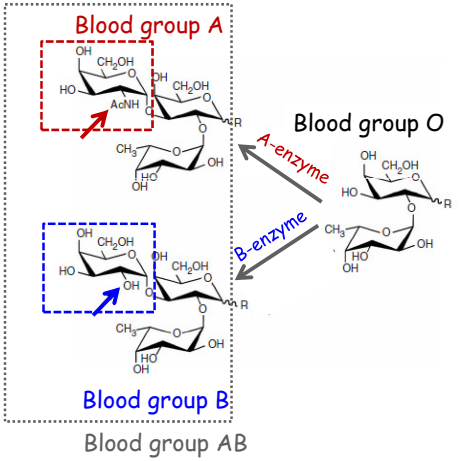
- **Lipids** (phospholipids, sphingolipids, glycolipids, cholesterol)
- **Proteins** (transmembrane, lipid anchored, peripheral)
- **Carbohydrates** (covalently bound to lipids and proteins, on the *outside face of the membrane*)



DTU

Blood group is determined by carbohydrate structures on the surface of blood cells

- ABO system
- Carbohydrate structures on **glycoproteins and glycolipids** are determined by genes (which code for proteins…)
- **Example:** A person with blood group A has antibodies against type B blood cells and can only tolerate blood transfusion with blood from group A- or O, not B or AB



DTU

Membranes are diverse in composition (and function)

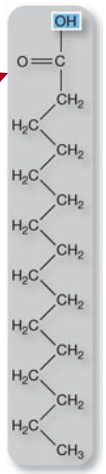
- Myelin (an insulating membrane that surrounds nerve cells) contains 18% protein and 76% lipid
- Mitochondrial inner membrane contains 76% protein and 24% lipid

DTU

Lipids (Ch3)

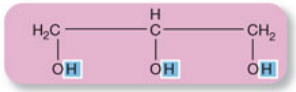
- Water insoluble
- Hydrophobic

A fatty acid



- Phospholipids: composed of two fatty acids esterified to glycerol, a phosphate group and polar "head group"

Glycerol

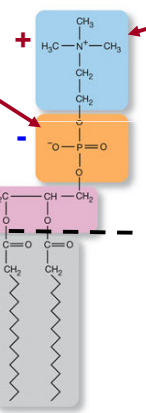


DTU

Phospholipids

Hydrophilic "head"

- Choline, serine, ethanolamine or similar (often positively charged)
- May contain carbohydrate
- Phosphate (negative charge)
- Glycerol

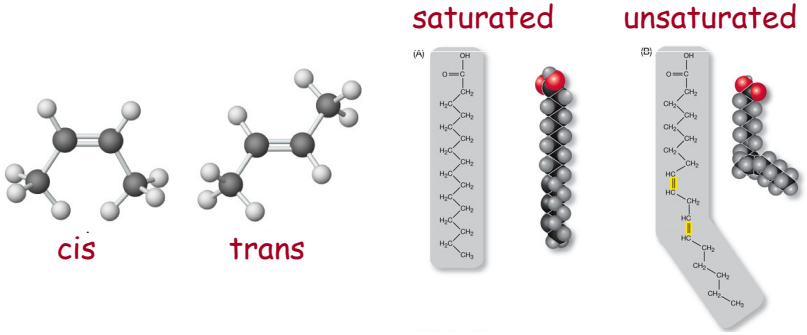


Two hydrophobic "tails"

Fatty acids, varying length, may be unsaturated (contain double bonds)

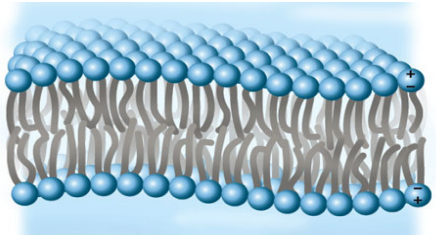
Degree of saturation is important for lipid structure and function

- Unsaturated fatty acids can contain *Cis*- or *trans*- double bonds



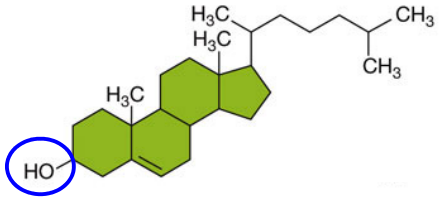
Phospholipids form a bilayer structure

- The lipid bilayer is *fluid:* individual lipid molecules can move laterally within the bilayer
  - Shorter fatty acid chains make the bilayer more fluid
  - The presence of *cis*- double bonds (unsaturated fatty acids) makes the bilayer more fluid
- Lipid molecules *cannot* "flip" from one side of the bilayer to the other



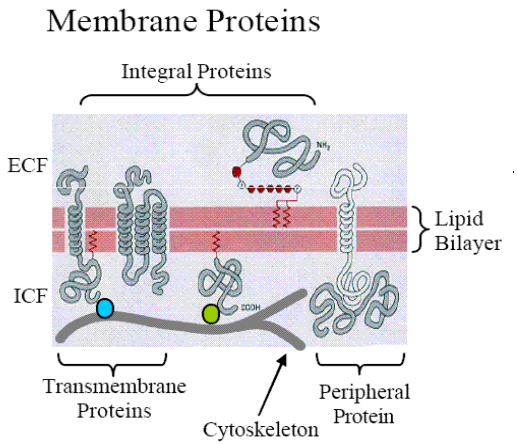
Cholesterol

- Hydrophobic, with a single hydrophilic OH-group
- Relatively rigid, so it makes the bilayer **less fluid**
- Prevents tight packing of neighbouring fatty acid chains, thereby **decreasing the melting temperature of the bilayer structure**

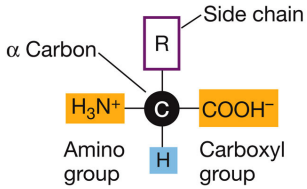


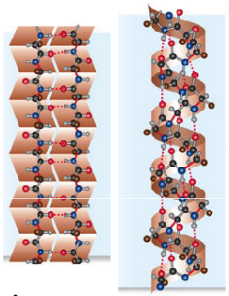
Membrane proteins

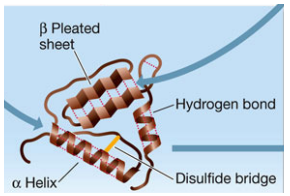
- **Integral**: bound to the hydrophobic part of the membrane
- **Peripheral**: bound to the hydrophilic surface of the lipid bilayer or to other membrane-associated proteins



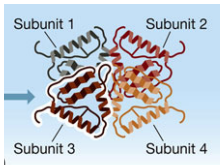
Protein structure (Ch 3)





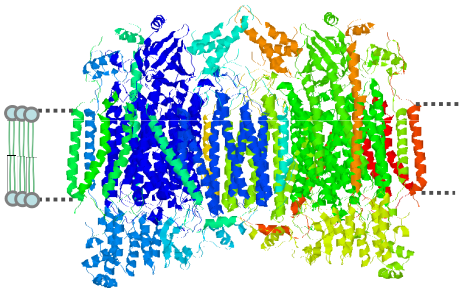


- 20 amino acids
- Secondary structure
- Tertiary structure
- Quaternary structure



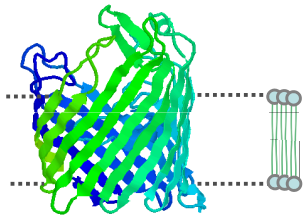
Transmembrane protein struktures

α-helix bundle



Cytochrome c oxidase from bovine mitochondrial inner membrane

β-barrel



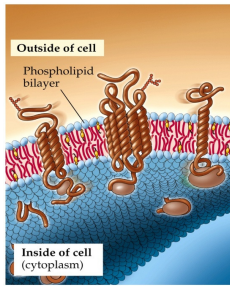
OmpF Porin from the outer membrane of *Escherichia coli*, a Gram-negative bacterium

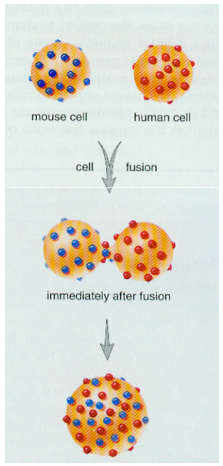
Functions of membrane proteins

- **Transport**:
  - Channels
  - Carriers
  - Active transporters
- **Cell recognition** and **antigen presentation**
- **Cell adhesion**, either to other cells or to extracellular matrix
- **Receptors** (processing of information)
- **Enzymes**
- **Energy transformations** (e.g. photosynthesis)

Diffusion of membrane proteins

- When two cells fuse, the membrane proteins from each cell can mix with each other

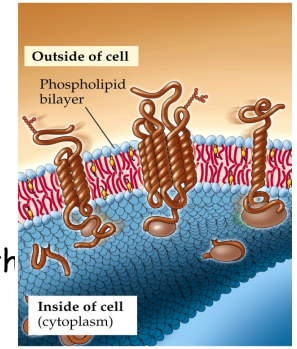




Three exeptions

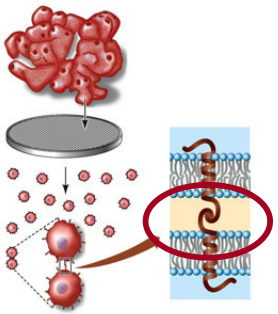
Free diffusion of membrane proteins can be hindered if

- The proteins are anchored to the cytoskeleton
- The proteins are located in a "*lipid raft*" (semi-fluid domain in th membrane that is rich in long-chain fatty acids and cholesterol)
- The cell forms "*tight junctions*" with neighbouring cells



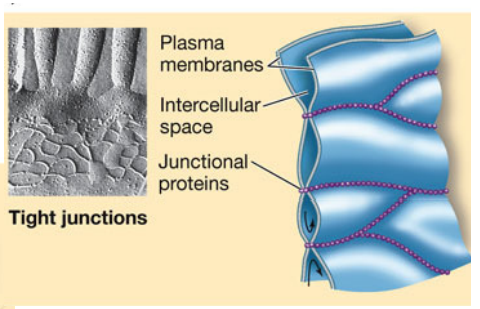
Cell adhesion 1

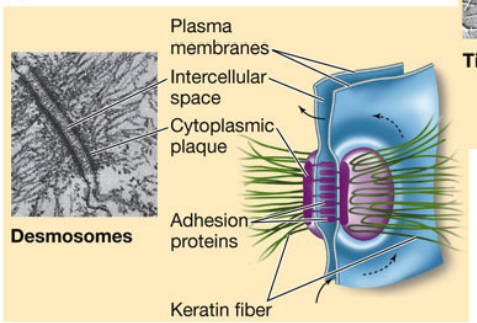
- Cell recognition is mediated by protein-protein interactions



Cell adhesion 2

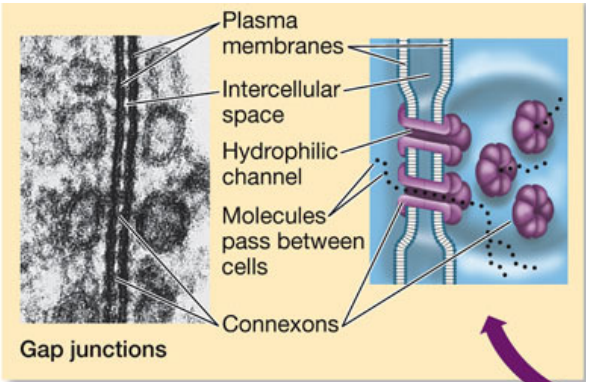
- Tight junctions and Desmosomes





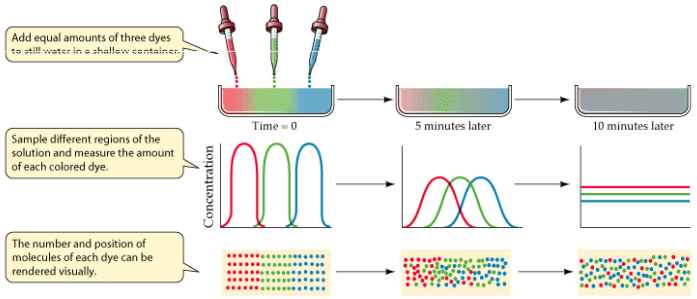
Cell adhesion 3

- Gap junctions



Diffusion

- Dissolved molecules show a net movement along a **concentration gradient** (from an area of high concentration to an area with lower concentration)



Membrane permeability

- Water and small, relatively non-polar molecules (e.g. ethanol) can cross the membrane by simple diffusion.
- Ions and macromolecules can't penetrate the membrane without help from transport proteins

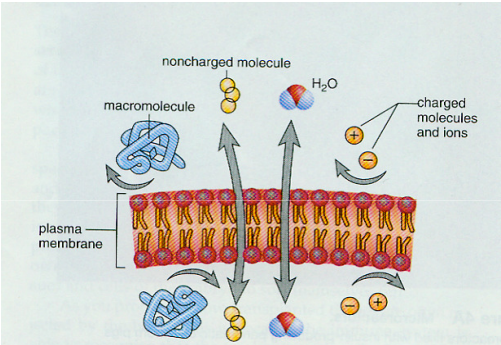
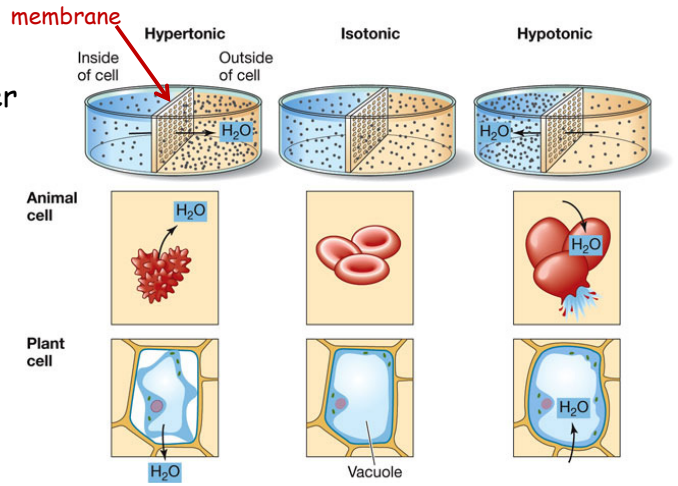


Figure 4.4 **How molecules cross the plasma membrane.** The curved arrows indicate that these substances cannot cross the plasma membrane and the back and forth arrows indicate that these substances can cross the plasma membrane.

Osmosis

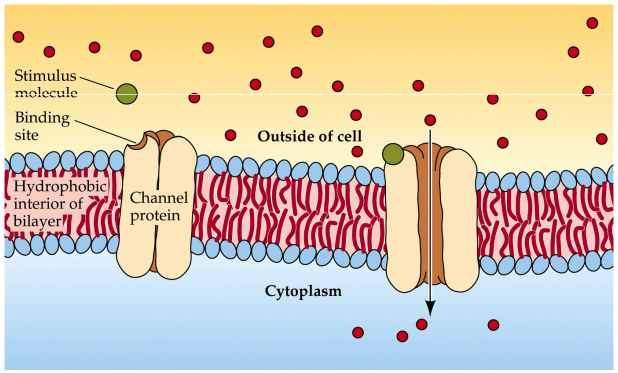
When diffusion of salts and other solutes is prevented by a membrane…

…the concentration difference must be equalised by other means, and water moves along it's concentration gradient



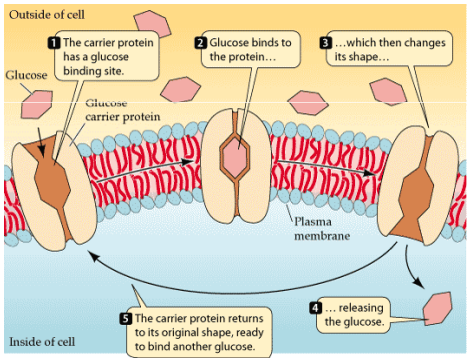
Channels: *Facilitated diffusion*
(Passive transport)

Channels can open or close in *response* to a *stimulus* (chemical or electrical).



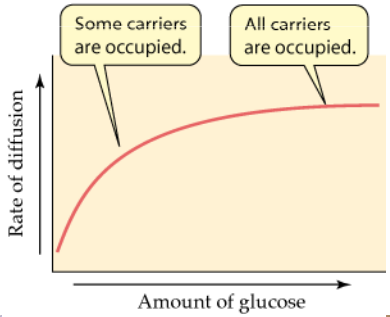
Carriers: *Facilitated diffusion*
(Passive transport)

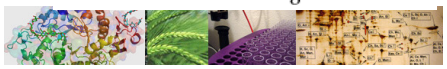
- In contrast to a channel, a carrier changes conformation in order to allow passage of a specific molecule



Carriers: *Michaelis-Menten kinetics*

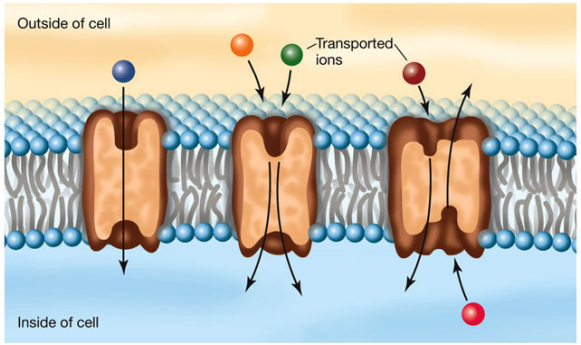
When the concentration of the transported molecule is high, binding sites on the carrier protein become *saturated*





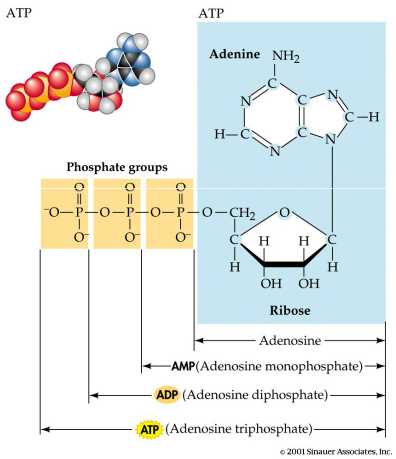
Active transport

- Active transporters can be *uniporters*, *symporters* eller *antiporters*

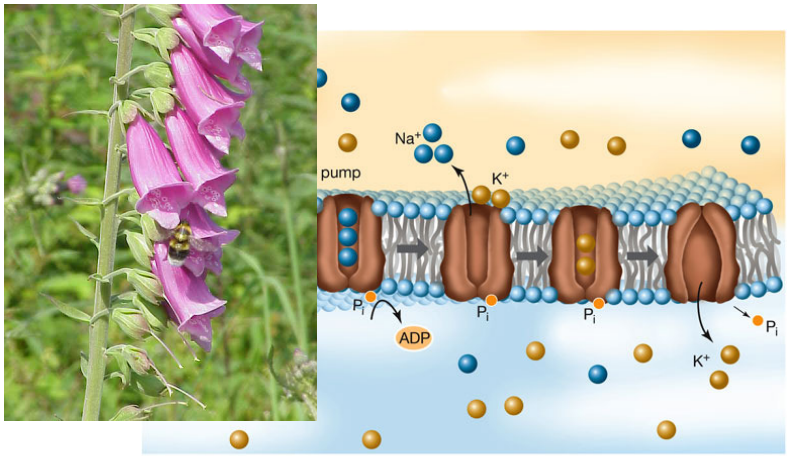


Primary active transport: ATP

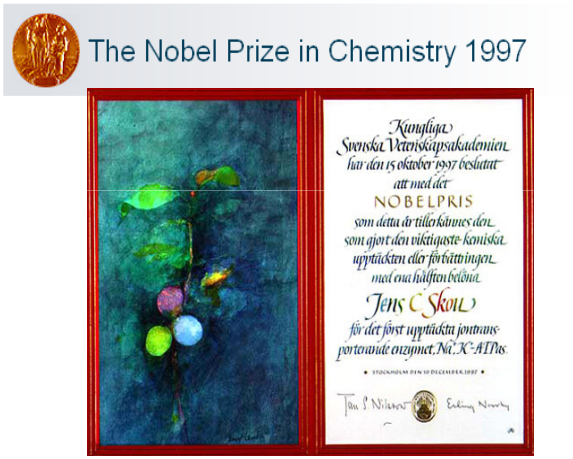
- ATP (Adenosine triphosphate) is the universal "energy currency" of the cell
- Energy for primary active transport is obtained from hydrolysis of ATP to ADP and free phosphate:
- **ATP → ADP + Pi**



Primary active transport: Sodium-Potassium pump



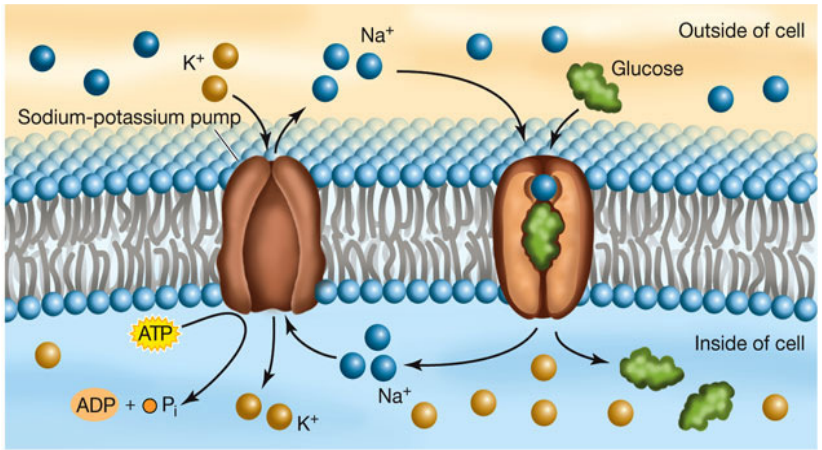
Sodium-Potassium pump : Jens C. Skou



"for the first discovery of an ion-transporting enzyme, Na+, K+ -ATPase"

Jens C. Skou
1/2 of the prize
Denmark
Aarhus University
Aarhus, Denmark

Secondary active transport:
A sodium gradient drives uptake of glucose



Transport across membranes

	Simple diffusion	*Facilitated diffusion (passive transport)*	*Active transport*
Direction (along/ against conc. gradient)			
Energy source			
Membrane protein needed?			
Specific?